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Temperature distribution in a nailed gypsum-stud connection exposed to fire

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As part of a structural system, the stud wall sheathed with gypsum helps resist in-plane buckling and racking. Currently the fire performance of these systems can be determined only through full-scale fire tests, which are expensive. The stud wall structural performance is dependent on the nailed connections between the sheathing and framing members. However, the performance of the connection while exposed to intense thermal loads such as that due to fire is unknown. To what extent the connection changes during exposure to elevated temperatures is a question of interest.

To determine the connection performance under elevated temperatures, information is needed about the mechanical properties and the temperature distribution of the connection along the nail that joins the gypsum panel to the stud. This report on the temperature distribution along the nail is one part of a three-part study concerned with the connection performance. To accomplish this goal, a finite element model was used to predict the thermal performance of the connection as well as to determine the influence various materials had on the results. To confirm the results by recording temperatures, actual test samples were exposed to the ASTM E 119 testing procedures.

The connection is symmetric along the longitudinal axis. This greatly reduced the finite element calculations by confining the analysis to only on quadrant of the connection. Eight node isoparametric elements were used to represent the three materials: gypsum, wood, and steel. The thermal load was applied through use of radiant elements to represent the fire. The mass and physical properties of the wood and gypsum were adjusted during the analysis to accommodate the loss of moisture. Five different cases were run to determine the influence a layer of air present between the stud and gypsumboard had on the temperature gradient as well as the influence of the nail length, type of gypsum, and species of the wood stud.

The samples exposed to the ASTM testing was composed of Douglas-fir studs, regular gypsumboard, and five-penny sheetrock nails. Six thermocouples were placed within and near the connection.

It was determined that the amount of heat transferred through the gypsumboard into the stud was insignificant compared to the heat transferred through the nail. The temperature increased quickly within the nail and in the wood immediately adjacent to the nail where as the remaining wood was not significantly affected. The gypsum adjacent to the nail and near the exposed surface reached the temperature of calcination early in the testing. Because gypsum experiences calcination, the structural integrity is affected and may determine the total connection mechanical performance. It was also determined that wood species, type of gypsumboard, and nail length did not change the temperature distribution significantly

The case run in which the materials were the same as the fire test samples showed excellent agreement in the temperature gradients. The results of the different case runs were able to be used in further studies to help determine the mechanical performance of a single connection at elevated temperatures.

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